Anonymous Referee #2

RW2: Cartier et al. present a novel diatom ∂18O dataset spanning the past ~5000 yrs from Lake Petit in the SW French Alps. The focus of the study lies in the local to regional characterization of hydroclimate perturbations around the 4.2ka climatic event and is thus relevant within the scope of CP. The oxygen isotope data (4 data points for the time slice) show a clear excursion towards higher values, which the authors primarily interpret to be the result of drier conditions with increased evaporation in the Lake Petit watershed. By using already published data from a previous 'multiproxy' study of the Petit sediment record the authors further suggest that the period was characterized by precipitation induced flood events. While the interpretation of the oxygen isotope data appears mostly sound (detailed comments below) it is sometimes hard to follow the argumentation regarding the sedimentary indicators that suggest a higher frequency of flood events/catchment erosion during this period. Since this is quite a central statement for the hydrological reconstructions I would suggest the authors provide a complete lithostratigraphic account of the record (eg. Are there any discernible or identifiable flood layers?). In a broader sense the manuscript contributes an additional hydroclimatic dataset that will help to paint a regional picture of climate repercussions during the 4.2ka event in the Mediterranean borderlands. The manuscript is in most parts appropriately structured, in some parts appropriately illustrated, but suffers from a large number of spelling mistakes and grammatical flaws.

AC: We thanks the reviewer for its valuable comments to improve the quality of the manuscript. In general, the reviewer highlights the overall quality of the manuscript, the relevance of the dataset presented, and pertinence of the interpretations as a significant new contribution to draw a more precise picture of the 4.2 ka BP event. Also, the reviewer points out several needs for clarifying the manuscript:

- To better describe the previous published dataset on core PET09P2, in order to assist, and restrict, the interpretations of the $d^{18}O$ data;
- To improve the overall writing quality of the manuscript.

We fully agree the reviewer's comments (all details given below), and will modify the manuscript in accordance.
We particularly realized that the term "flood" is somewhat confusing in the manuscript, compared to the recent similar literature in paleolimnology. The term "flood" was mentioned twice in the manuscript (chapter 5.2, lines 6 and 17): first to designate a hydrological process (water overflow of a river channel); second to describe a sedimentological facies (minerogenic normal-graded layer). No "flood layers" are deposited in PET09P2 at the difference of some other lake sediment records of this region, noticeably in Lake Allos that has been the most recently investigated for that purpose (Brisset et al., 2017; Wilhelm et al., 2012). At Lake Allos, the flood layer facies correspond to 60% of the material deposited over the last 7000 yrs. Comparing those two records, Lake Petit and Lake Allos is not straightforward, and probably, has led to the confusions noted by the reviewer.

Those clarifications will be done in the manuscript by including a detailed description of the lithostratigraphy of the Lake Petit and sedimentation processes, referring more precisely to the complementary dataset published by Brisset et al. (2013).

RW2: Site settings - the seasonal distribution is quite important in this setting. If possible provide precipitation data for summer and winter months. Also, what controls winter snow depth in this setting? From the data presented it seems as if snow depth (by the end of the season?) varies largely from year to year.

AC: Based on the meteorological station of Malaussène (500 m a.s.l; the closest station to Lake Petit) that covers the period 1997-1998, the precipitation regime in this area is characterized by a marked intra-annual variability, because of the influence of the Mediterranean climate regime. Precipitation essentially occur in spring and autumn (an average of 80 % of the total precipitation volume of the year, corresponding to 758 mm). Snow cover duration is about 185 days at the altitude of Lake Petit from November to April (Durand et al., 2009).
The origin of precipitation vary along the year: while rainfall has a Mediterranean origin (54% of the rainfall events, Celle-Jeanton, 2001), winter snowfalls are essentially associated with northwest atmospheric flows (Durand et al., 2009).

An ombrothermic diagram will be added in the Fig. 1 to make it clear for readers.

RW2: p.4, l. 1-4. Temperature dependent fractionation of rainfall is suggested as the main driver of seasonal oxygen isotopic composition. However, ∂18O of precipitation at Malaussene is lower (by almost 1per mill) during summer and higher during winter-please explain.

AC: Thanks to have point out this mistake. According to the GNIP database, the mean $\delta^{18}O_p$ at the meteorological station of Malaussène is of -4.9 ‰ in summer and of -5.8 ‰ in winter.

RW2: Material and methods - please provide a more complete description of the lithology of the record. Are there any discernible flood layers present? If so, does the frequency and/or the flood layer thickness increase during the respective time interval?
- have event layers (e.g. flood layers) been removed prior to the construction of the age model? - a new age-modelling algorithm has been applied to the Lake Petit core please provide an age-model figure.

AC: The sediments of the core PET09P2 consist in changes in the relative abundance of a biogenic silica lacustrine production (diatoms), an organic production (essentially algal, e.g. Hydrogen-index comprised between 450 and 575 HC/TOC), and a terrigenous minerogenic clay fraction (Brisset et al., 2012; 2013). The sediments deposited during the period at 4.2 ka are characterized by a higher proportion (80%) and a higher flux of the terrigenous fraction (Brisset

et al., 2013), while the diatom-organic component drop to lower but still significant concentrations (20%).
This unit does not correspond to one or to a cluster of “flood layers”, as defined by sedimentological criteria (e.g. Mulder and Chapron, 2011; Gilli et al., 2013): grain-supported sediments, having a distinct – possibly erosional - contact with the previously deposited sediments, and characterized by a normal-graded grain-size sequence. No “flood layers” are deposited in PET09P2 at the difference of some other lake sediment records of this region, noticeably in Lake Allos that is the most recently investigated one on that topic (Brisset et al., 2017; Wilhelm et al., 2012); at Lake Allos, flood layer sedimentological facies, corresponds to 60% of the material deposited over the last 7000 yrs. Characteristics of the lake catchment likely explain the total absence of flood layers. Catchment slopes of Lake Petit are smoothly eroded (morphologies inherited of glacier abrasion processes shaping the glacial step in resistant crystalline rocks), and the gradient of the main river stream is relatively low (10°). These topographic characteristics do not favor surface water concentration to generate a sufficient-water discharge to carry coarse particle.
To clarify those points, the detailed lithological information will be added in the manuscript and the Fig. 4 will be complemented of the lithostratigraphic log.

The age-depth model presented in this study is indeed a new algorithm not published yet, and part of the present paper. The value of the algorithm “bacon” developed by Blaauw and Christen (2011) is to calculate the age probability density function of the data proxy. In the present paper, applying this approach is necessary to demonstrate that the 4.2 event is well constrained in the PET09P2 core (that is a minimum), and interestingly plus: the event cannot be instantaneous in time, and its time range is at a confidence interval of 95% of probability of > 25 years and < 660 years. Given these valuable results, we decided to recalculate the model (done using the “clam” R package in Brisset et al., 2013) by a model calculated using the ‘bacon’ R package (Blaauw and Christen, 2011).
We agree that adding the all details of this new model in the manuscript will contribute to a better understanding of the overall dataset and include those information in the revised manuscript.

RW2: Discussion - p. 6 l. 3-6: Why start with human impacts if you can rule those out for the respective time interval? Emphasizing the different factors influencing the hydrological setting is more important in the context of the study- I suggest to start the discussion with those.

AC: Following the comment of the reviewer, the first sentences concerning human impacts have been removed. The discussion starts with a description of the rise in $\delta^{18}O_{diatom}$ during the 4.2 ka BP event and the main factors influencing oxygen isotopes (changes in water temperature and $\delta^{18}O_{lake\ water}$).

RW2: Somewhere in the discussion (and in the site description section) it would be worth noting that the water residence time is short.

AC: We will add in the site settings that according to the size of Lake Petit the water residence time is expected to be short even if we don't have a quantitative estimate.

RW2: P. 6, L. 27-28: 'Today, Mediterranean precipitation favours runoff and erosion in steep areas (Kosmas et al., 2002)'. Please specify more precisely what type of precipitation favours (intense) runoff and flooding. Also the seasonal distribution of this type of precipitation is important here.

AC: According to a synthesis of floods and flash flood events in Mediterranean countries different types of precipitation favour intense runoff: short and local summer flash flood event, autumn high-rainfall event and extended rainfall event affecting more than one country (Llasat et al., 2010). In this study 185 flood events (daily accumulated precipitation over 60 mm) on the period 1990-2006 were distributed as follows: 54.7 % of the annual total occurred in autumn (September, October and November) while the summer months have 17.2 % and winter 15.3 %. In addition, Descroix et al. (2010) has shown that soil erosion is higher after long periods of drought.
These more detailed information will be inserted in the manuscript.

RW2: P. 6, L. 28-31: 'Geochemical data showing high terrigenous inputs to Petit Lake between 4400 and 4000 cal. BP (Fig. 4), interpreted as an increase of runoff in the watershed (Brisset et al., 2013), are thus consistent with a greater seasonal variability of the Mediterranean climate characterised by intense precipitation occurring in fall and spring and significantly drier periods in the summer months (Durand et al., 2009)'.
The statement of changes in seasonality is not supported by the data. Wouldn't an increase in convective precipitation during summer with Mediterranean moisture sourcing also explain both an increase in @18O and catchment erosion induced by heavy precipitation events. Also, snow cover in early spring would probably inhibit catchment erosion, leaving only heavy precipitation events in summer and early fall to explain an increased erosion pulse.

AC: Higher terrigenous inputs to Lake Petit during the 4.2 ka BP event highlighted the presence of intense precipitation events during the ice-free season which last in average from April to October. Therefore, we support the hypothesis that the precipitation regime has changed during this period of the year to produce the changes in erosion processes. According to Durand et al. (2009), precipitation in southern Alps occur mainly in Spring and Autumn. At the scale of the Mediterranean region, 54.7 % of heavy precipitation occur in Autumn (Llasat et al., 2010). Convective precipitation events from Mediterranean moisture sourcing are of higher occurrence during these months when air masses from the Mediterranean, still warm and humid meet the cold air masses from the Atlantic.

We agree with the reviewer that this sentence is mixing several ideas and that changes in seasonality can't be assessed precisely during the ice-free season. For this purpose, we have improved the discussion on the isotopic interpretation by adding sub-sections for each factor of interest including changing in snow contribution, precipitation regime and sourcing (refer to the answer to the reviewer 1).

RW2: P.7, l. 6-8: 'In summary, the rapid increase in $\delta^{18}O$ diatom from 4400 to 3900 cal. BP is most likely the result of an increase in water evaporation possibly associated with a shift in precipitation origin and distribution over the year. This state lasted for ca. 500 years'. I am not sure I can follow the reasoning here entirely as it is also in part contradictory to the statements made earlier on in the discussion. For example, on page 6 you explain the increase in catchment erosion by an increase in spring and fall precipitation (that is similar compared to today), now here you propose 'a shift in distribution over the year'. Also stronger evaporation is suggested as the main cause for the observed $\delta^{18}O$ signal. However, the increase in erosion is probably best explained by more frequent and intense summer precipitation events and/or local expansion of glaciers/icefields (glacial cirque just above the lake). I think this is not all wrong but I would suggest the authors to 1) take a look at other records aiming at heavy precipitation reconstructions in nearby sites for the respective time interval, what do the authors of those studies suggest in terms of precipitation type and seasonal distribution? 2) some studies have suggested moderate glacier advances during this period. Wouldn't persistence of snow/ice throughout the summer also influence the hydrological budget of the lake? And at the same time deliver erodible substrates to the lake? The lake is located just below a glacial cirque which appears to have been active not too long ago. I suggest expanding on this somewhat as this is central to the interpretation of the dataset presented.

AC: According to the geochemical data, the signature of the alumino-silicate fraction indicates high cation fractionation characteristic of pedogenetic origin. At Lake Allos (close to Lake Petit), no evidence of increasing flood frequency has been recorded around 4.2 ka BP but it has been shown that erosion was inhibited prior to deforestation and dismantling of soils by human activities at ca. 1700 cal. BP (Brisset et al., 2017). A synthesis of flood frequency across the Central Alps has shown evidence of increasing flood frequency from 4.2 ka BP to 2.4 ka BP and during the Little Ice Age certainly linked to a southerly position of the N-Atlantic circulation (Wirth et al., 2013). In their study sites, they interpreted flood records to be mainly a record of spring and fall events. These general wetter conditions across the Alps might have been a factor of decreasing $\delta^{18}O_{diatom}$ after the 4.2 ka BP event and during the Little Ice Age (fig. 3). During the 4.2 ka event at Lake Petit, we argue that the intensity of precipitation increased during the ice-free season but not necessarily the occurrence of events. $\delta^{18}O_{diatom}$ values suggest a higher contribution of ^{18}O enriched precipitation of Mediterranean origin to the lake water balance (refer to the answer to reviewer 1).
We agree with the reviewer that some studies have recorded moderate glacier advances in central western Alps and in the northern Alps but not, for now, in the Mediterranean Alps (Le Roy, 2012; Ivy-Ochs et al., 2009). According to the last review for the Mediterranean Alps (Brisset et al., 2015) the Holocene re-activation of glaciers has been dated 2720-2360 cal. BP (Ribolini et al., 2007). Rock glacier activities are also recorded later during the Little Ice Age which can explain why the glacier cirque appears to have been active not too long ago

(Federici and Stefanini, 2001). By looking at the isotopic record, the lowest value of $\delta^{18}O_{diatom}$ is during the Little Ice Age possibly due to wetter conditions during this period associated with higher snow contribution from the Atlantic. A persistence of snow during summer which has a low $\delta^{18}O$ signature would most likely lowered $\delta^{18}O_{diatom}$ contrary to what is observed during the 4.2 ka BP event. We will add more reference in the manuscript to reconstructions of glacier advances and heavy precipitation in the Southern Alps.

RW2: P. 7, l. 27-28: Based on the interpretation suggestions above chemical weathering of soils is unlikely to intensify during the proposed climate conditions. Rather soils that formed during wetter and warmer climate phases prior to the 4.2ka event were subject to erosion, resulting in the input of more weathered soil material into Lake Petit. Please revise.

AC: In the paper of Brisset et al., 2013 sedimentological data have been interpreted as follows: from 4700 to 4200 cal. BP a period of low detrital supply, high fractionation of cations suggesting the presence of developed acid soils in the watershed and high chemical weathering; during the 4.2 ka BP event: a maximum of clay detrital supply and high fractionation of alumino-silicates highlighting a dismantling of the former developed weathered soils.
We will revise this sentence to say that the high fraction of alumino-silicates during the 4.2 ka BP event is more likely the result of dismantling weathered soils formed during the previous period. A decrease of chemical weathering during the 4.2 ka BP event is possible due to drier conditions.

RW2: P. 8, l. 12-29: This paragraph is simply a listing of quotes from references. Please integrate these with your data in a discussion style.

AC: We will improve this part of the manuscript to follow the suggestion of the reviewer.

RW2: p. 9, l. 10-11: 'The new 18Odiatom record for Petit Lake was used to reconstruct past hydrological changes and decipher climatic implications from local human impacts around 4200 cal. BP.'
The study focuses on reconstructing hydrological changes, it does not touch upon human impacts. Please revise.

AC: This publication is following several papers on Lake Petit (Brisset et al., 2012; Brisset et al., 2013; Cartier et al.,2015) we wanted to highlight the fact that the use of oxygen isotopes from diatoms allowed us to confirm the effect of climate on the environmental change observed at Lake Petit at that time.

RW2: p.9, l. 23-25: 'This isotopic record at Petit Lake has revealed the implication of the 4.2 kyrs event in abrupt ecosystem changes in the Southern Alps and is useful to better understand the intensity and geographical extent of this climatic event in the Mediterranean region.'
Again, this study, as is, focuses almost exclusively on hydrological changes. If the authors would like to include impacts of hydrological change on ecosystem changes

than this part has to be developed throughout the manuscript and not only in the conclusions.

AC: We will change this sentence by "This isotopic record confirms the implication of the 4.2 ka BP event in the environmental responses observed at Lake Petit in previous studies (Brisset et al., 2013; Cartier et al., 2015)". The summary of environmental changes during the 4.2 ka event is present in part 5.2. The detailed results of environmental responses are presented in previous papers.

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